



US009219813B2

(12) **United States Patent**
Deasy et al.

(10) **Patent No.:** **US 9,219,813 B2**
(45) **Date of Patent:** **Dec. 22, 2015**

(54) **PROVISIONING WORK ENVIRONMENTS ON
PERSONAL MOBILE DEVICES**

(71) Applicant: **VMware, Inc.**, Palo Alto, CA (US)

(72) Inventors: **Stephen Deasy**, Brighton, MA (US);
Craig Newell, Cambridge, MA (US); **Paul**
Emil Sit, Cambridge, MA (US); **Paul**
Wisner, Arlington, MA (US); **David**
Furodet, Pontcharra (FR); **Viktor**
Gyuris, Newton, MA (US); **Robert**
Meyer, Harvard, MA (US); **Fanny**
Strudel, Brignoud (FR)

(73) Assignee: **VMWARE, INC.**, Palo Alto, CA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/678,964**

(22) Filed: **Nov. 16, 2012**

(65) **Prior Publication Data**

US 2013/0130651 A1 May 23, 2013

Related U.S. Application Data

(60) Provisional application No. 61/562,979, filed on Nov.
22, 2011.

(51) **Int. Cl.**
H04M 1/66 (2006.01)
H04M 1/68 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04M 1/72583** (2013.01); **B32B 37/16**
(2013.01); **C09J 7/041** (2013.01); **G06F 3/0482**
(2013.01); **G06F 3/04842** (2013.01); **G06F**
9/445 (2013.01); **G06F 9/455** (2013.01);
(Continued)

(58) **Field of Classification Search**

CPC H04W 8/245; H04W 12/02; H04W 12/08;
H04M 1/72577
USPC 455/410-411, 412.1, 414.1-414.2,
455/418-420, 566
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,188,243 B2 3/2007 Shell et al.
7,941,510 B1 * 5/2011 Tormasov et al. 709/220
(Continued)

FOREIGN PATENT DOCUMENTS

WO 2007149671 A2 12/2007
WO 2009147631 A1 12/2009

OTHER PUBLICATIONS

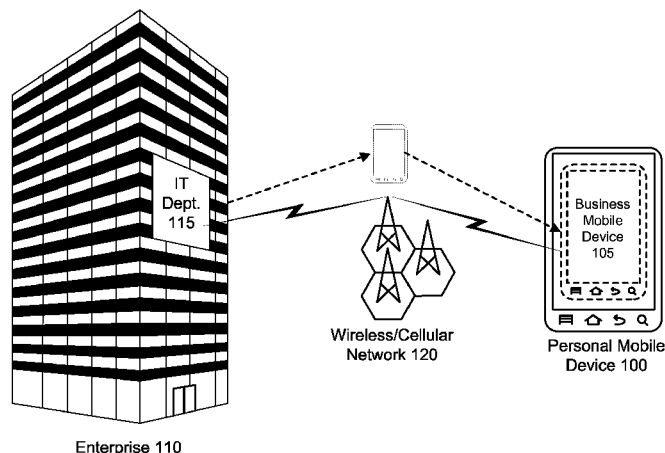
International Search Report, PCT/US2012/065899, Apr. 9, 2013.

Primary Examiner — Simon Nguyen

(57) **ABSTRACT**

A virtual business mobile device can be provisioned on a personal mobile device, by binding a mobile application for provisioning the business mobile device to a privileged component of a host operating system of the personal mobile device, wherein the binding enables a hypervisor component and a management service component of the mobile application to execute in a privileged mode. The mobile application is then able to download a virtual phone image for the business mobile device and security-related policy settings relating to use of the business mobile device from a mobile management server, wherein the hypervisor component is able to launch a virtual machine for the business mobile device based on the virtual phone image. Once the virtual phone image has been downloaded, the management service component initiates a periodic attempt to establish a connection with the mobile management server to comply with the downloaded security-related policy settings.

34 Claims, 10 Drawing Sheets



- (51) **Int. Cl.**
- | | | | | | |
|--------------------|-----------|-------------------|---------|-------------------|---------|
| <i>H04M 3/00</i> | (2006.01) | 2006/0003770 A1 | 1/2006 | Park | |
| <i>H04M 3/16</i> | (2006.01) | 2006/0080392 A1 * | 4/2006 | Kawakami et al. | 709/206 |
| <i>H04B 1/38</i> | (2015.01) | 2006/0182104 A1 * | 8/2006 | Lee et al. | 370/389 |
| <i>H04M 1/00</i> | (2006.01) | 2006/0224742 A1 | 10/2006 | Shahbazi | |
| <i>H04M 1/725</i> | (2006.01) | 2007/0198656 A1 * | 8/2007 | Mazzaferri et al. | 709/218 |
| <i>C09J 7/04</i> | (2006.01) | 2007/0298767 A1 | 12/2007 | Brown et al. | |
| <i>B32B 37/16</i> | (2006.01) | 2008/0070495 A1 | 3/2008 | Stricklen et al. | |
| <i>H04W 12/06</i> | (2009.01) | 2008/0125102 A1 | 5/2008 | Abel et al. | |
| <i>H04W 12/08</i> | (2009.01) | 2008/0201479 A1 * | 8/2008 | Husain et al. | 709/227 |
| <i>H04W 4/00</i> | (2009.01) | 2009/0113110 A1 | 4/2009 | Chen et al. | |
| <i>H04L 29/06</i> | (2006.01) | 2009/0164994 A1 | 6/2009 | Vasilevsky et al. | |
| <i>G06F 9/445</i> | (2006.01) | 2010/0132015 A1 | 5/2010 | Lee et al. | |
| <i>G06F 9/455</i> | (2006.01) | 2010/0146504 A1 | 6/2010 | Tang | |
| <i>G06F 3/0482</i> | (2013.01) | 2010/0223610 A1 | 9/2010 | Dehaan et al. | |
| <i>G06F 3/0484</i> | (2013.01) | 2010/0235881 A1 | 9/2010 | Liu et al. | |
| | | 2010/0279675 A1 | 11/2010 | Slack et al. | |
| | | 2010/0330961 A1 * | 12/2010 | Rogel | 455/411 |
| | | 2011/0107406 A1 * | 5/2011 | Frost et al. | 726/6 |
| | | 2011/0154431 A1 | 6/2011 | Walsh | |
| | | 2011/0209064 A1 * | 8/2011 | Jorgensen et al. | 715/733 |
| | | 2012/0246641 A1 * | 9/2012 | Gehrmann | 718/1 |
| | | 2012/0284712 A1 * | 11/2012 | Nimmagadda et al. | 718/1 |
| | | 2012/0289217 A1 * | 11/2012 | Riemer et al. | 455/418 |
| | | 2013/0023235 A1 * | 1/2013 | Fan et al. | 455/411 |
| | | 2013/0035063 A1 | 2/2013 | Fisk et al. | |
| | | 2013/0042234 A1 * | 2/2013 | DeLuca et al. | 718/1 |
| | | 2013/0042295 A1 * | 2/2013 | Kelly et al. | 726/1 |
| | | 2013/0080769 A1 * | 3/2013 | Cha et al. | 713/155 |
| | | 2013/0125113 A1 | 5/2013 | Do et al. | |
| | | 2013/0143522 A1 * | 6/2013 | Rege et al. | 455/405 |
| | | 2013/0145448 A1 * | 6/2013 | Newell | 726/7 |
| | | 2013/0217378 A1 * | 8/2013 | Danford et al. | 455/419 |
| | | 2014/0201743 A1 * | 7/2014 | Ali et al. | 718/1 |
- (52) **U.S. Cl.**
- CPC *H04L63/0272* (2013.01); *H04M 1/72522* (2013.01); *H04W 4/001* (2013.01); *H04W 12/06* (2013.01); *H04W 12/08* (2013.01); *Y10T 428/14* (2015.01)
- (56) **References Cited**
- U.S. PATENT DOCUMENTS
- | | | | |
|-----------------|--------|-------------------|-------|
| 8,233,882 B2 | 7/2012 | Rogel | |
| 8,528,059 B1 * | 9/2013 | Labana et al. | 726/5 |
| 8,539,556 B1 * | 9/2013 | Brandwine | 726/4 |
| 8,667,306 B2 | 3/2014 | Brown et al. | |
| 2003/0065676 A1 | 4/2003 | Gbadegesin et al. | |
- * cited by examiner

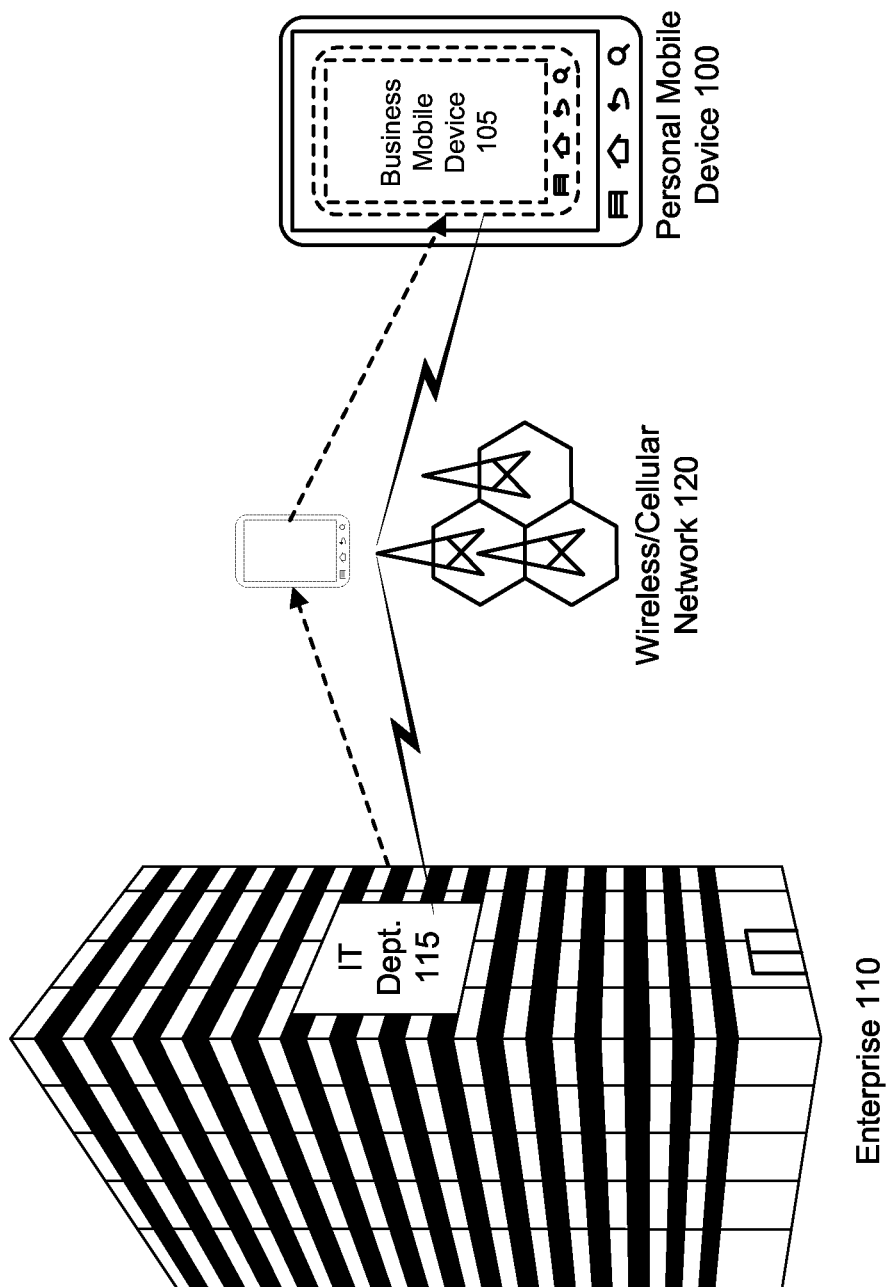


FIG. 1

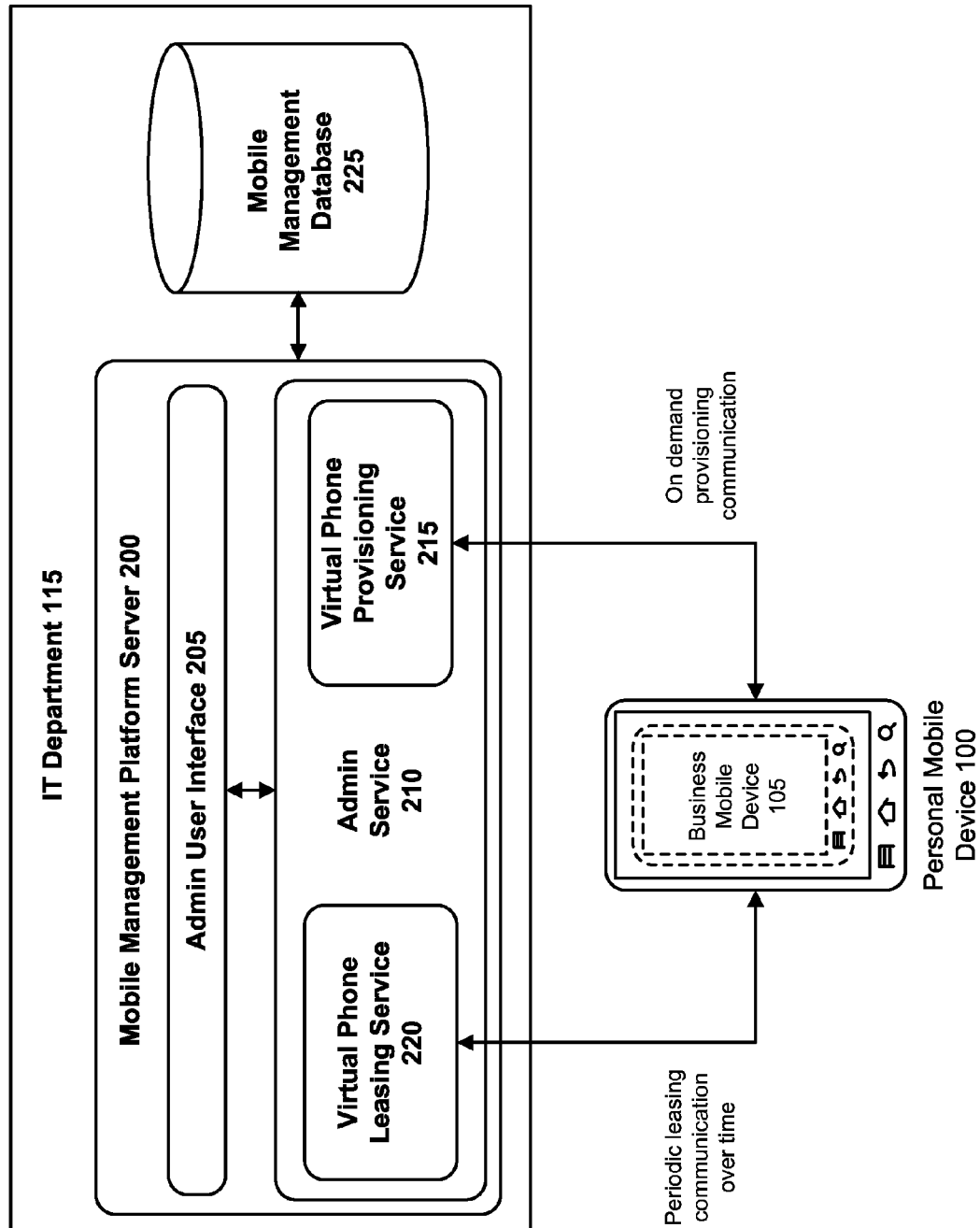


FIG. 2

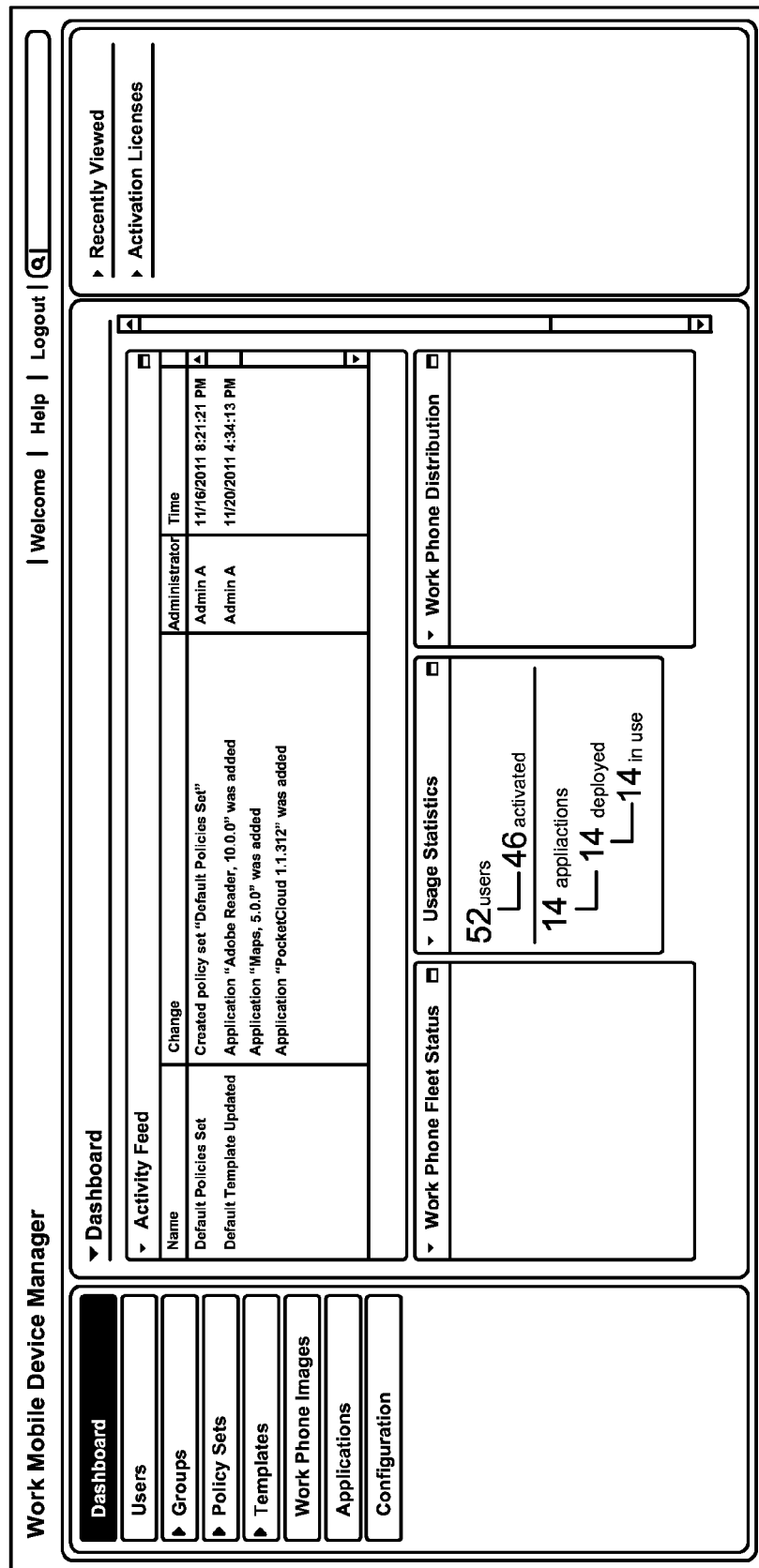


FIG. 3A

Work Mobile Device Manager

Welcome | Help | Logout

Q

Search Results (0)

Work Phone Users

Corporate Directory

Q

Name

Username

Group

Status

User A

usernameA

Sales

Active

User B

usernameB

Sales

Active

User C

usernameC

Marketing

Inactive

User D

usernameD

Engineering

Pending Install

User E

usernameE

Sales

Wiped

User F

usernameF

Legal

Active

User G

usernameG

Finance

Inactive

User H

usernameH

Sales

Active

User I

usernameI

Sales

Active

User J

usernameJ

Engineering

Active

User K

usernameK

Engineering

Active

User L

usernameL

Finance

Activated

User M

usernameM

Executive

Activated

User N

usernameN

Legal

Locked

User O

usernameO

Finance

Inactive

User P

usernameP

Marketing

Active

User Q

usernameQ

Sales

Active

User R

usernameR

Sales

Active

Dashboard

Users

Groups

Policy Sets

Templates

Work Phone Images

Applications

Configuration

Recently Viewed

Activation Licenses

FIG. 3B

Work Mobile Device Manager

Dashboard

Users

Groups

Sales

Marketing

Engineering

Create New Group

Groups

Templates

Work Phone Images

Applications

Configuration

Sales Group

Edit

Clone

Delete

View Change History

View Recently Viewed

View Activation Licenses

General

Name

Sales

Description

Mobile device users in the Sales Department

Policy Set

Default Policies Set

Template

Default Virtual Phone Template

Group Users

Name

Username

Group

Status

User A

usernameA

Sales

Active

User B

usernameB

Sales

Active

User H

usernameH

Sales

Active

User I

usernameI

Sales

Active

User Q

usernameQ

Sales

Active

User R

usernameR

Sales

Active

User T

usernameT

Sales

Active

User V

usernameV

Sales

Inactive

User AA

usernameAA

Sales

Active

User FF

usernameJJ

Sales

Locked

User JJ

usernameJJ

Sales

Pending Install

FIG. 3C

Work Mobile Device Manager

Welcome | Help | Logout |

Dashboard

Users

Groups

▼ Policy Sets

Default Policies Set

Create New Policy Set

Templates

Work Phone Images

Applications

Configuration

Default Policies Set

Edit

Clone

Delete

View Change History

▼ General

Name	Default Policies Set
Description	A default set of policies for Company X across all groups
Groups	Sales, Legal, Marketing, Engineering, Executive, Finance
Usage	500, 520

▼ Lease Renewal

Interval	12 Hours
Auto Disable	1 Day
Auto Wipe	4 Days

▼ Password

Require Passwd	Yes
Passwd Strength	PIN
Passwd Expiration	Never
Automatic Lock	5 Minutes
Max Retries	5

► Recently Viewed

► Activation Licenses

FIG. 3D

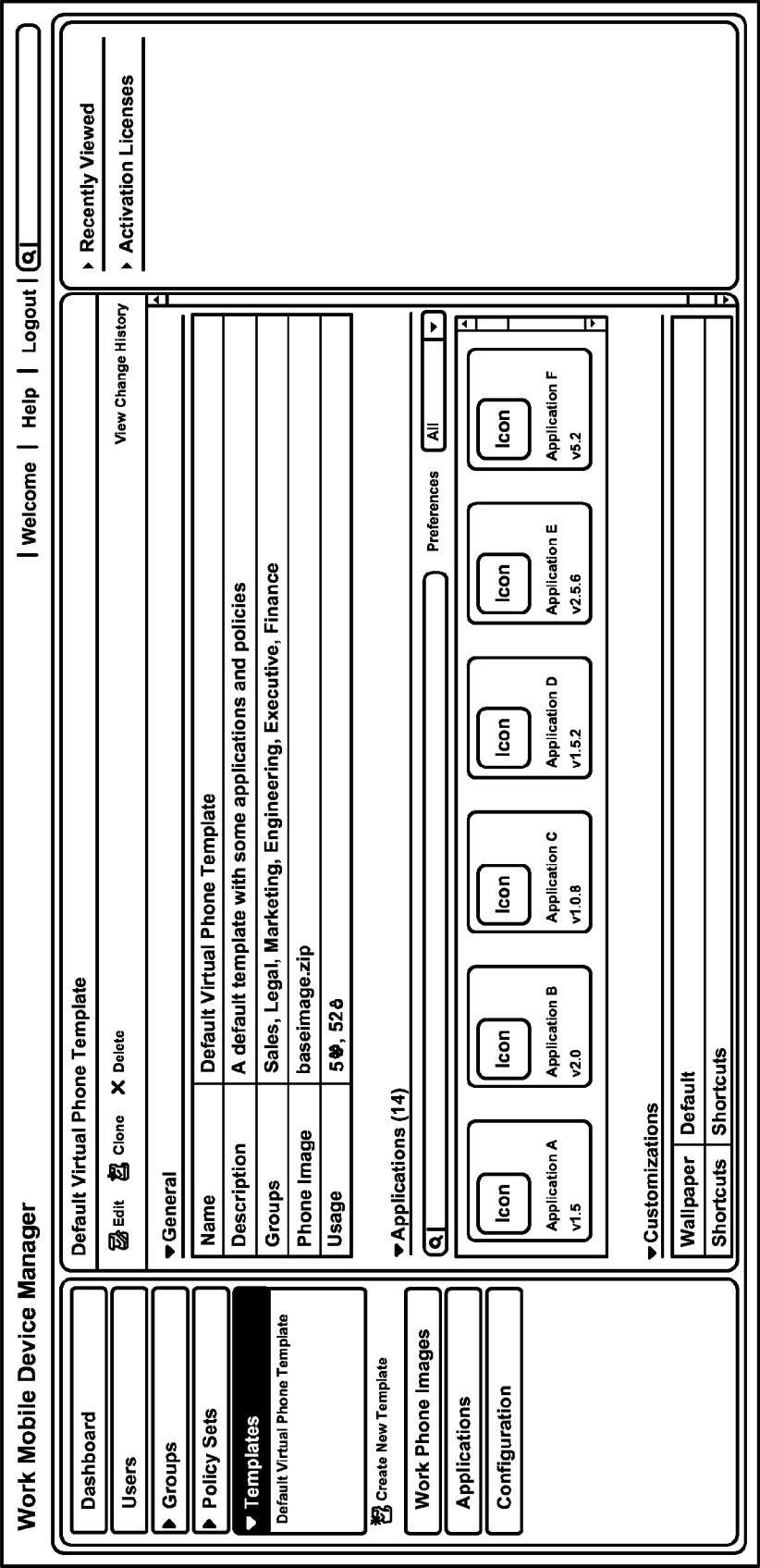


FIG. 3E

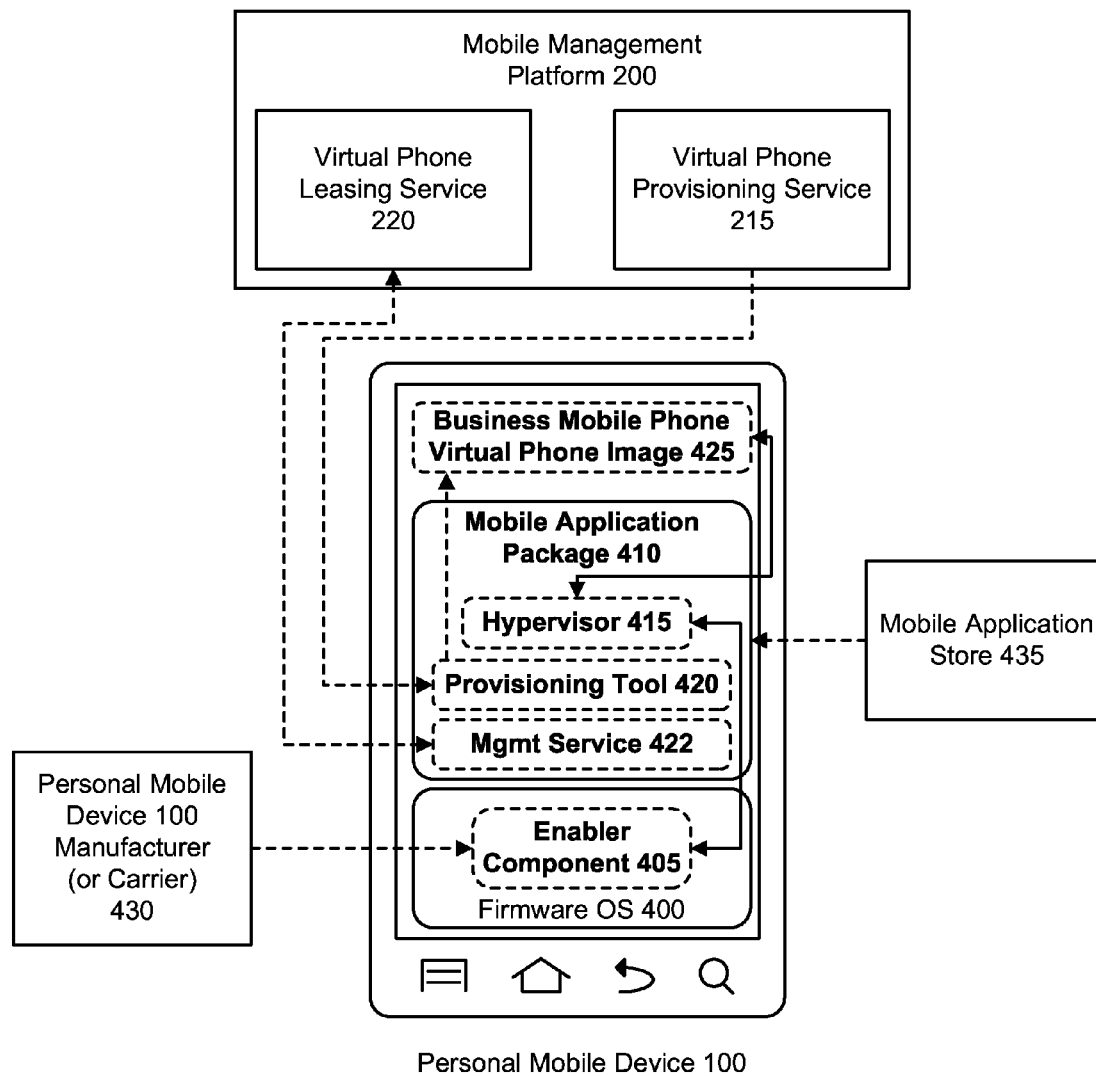


FIG. 4

Provisioning a Virtual Phone Image 425 for a Business Mobile Device 105 on a Personal Mobile Device 100

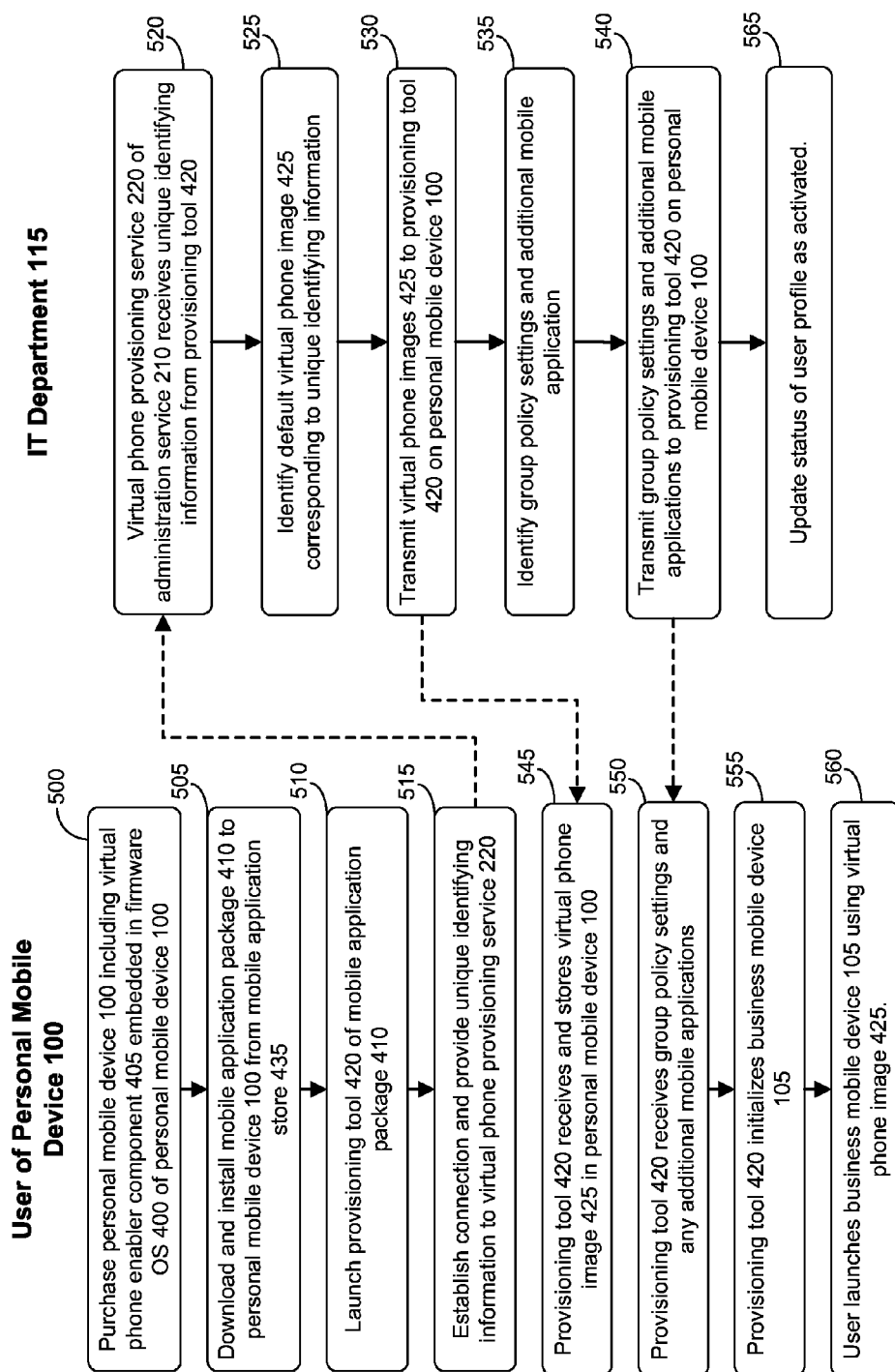
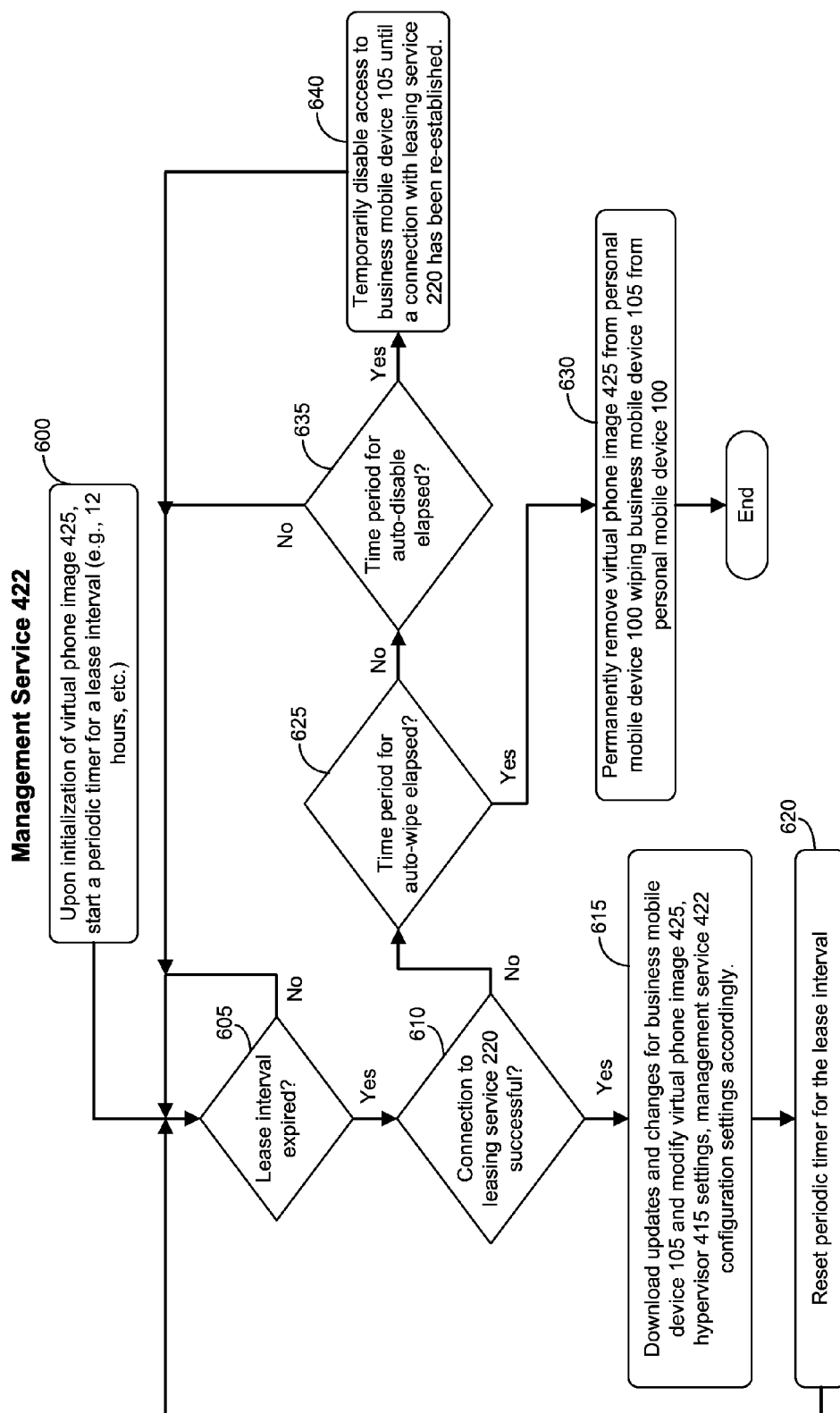


FIG. 5

Lease Communications By Management Service 422**FIG. 6**

PROVISIONING WORK ENVIRONMENTS ON PERSONAL MOBILE DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application 61/562,979 filed on Nov. 22, 2011 and entitled "Provisioning Work Environments on Personal Mobile Devices", which is hereby incorporated by reference. This application is also related to the patent applications entitled "Controlling Use of a Business Environment on a Mobile Device" U.S. Ser. No. 13/678,976 and "User Interface for Controlling Use of a Business Environment on a Mobile Device" U.S. Ser. No. 13/678,996, all of which are assigned to the assignee of this application and have been filed on the same day as this application.

BACKGROUND

Over the past decade, enterprises have experienced a substantial increase in the productivity of its workforce when providing them with business mobile devices. In the past, given their high cost, business mobile devices were mainly allocated to management and focused on providing employees with email access and cellular phone capabilities. However, recent improvements in the computing power, mobile display technologies and connection speeds of mobile devices, combined with the continued decreases in hardware costs, have made powerful mobile devices available even to the general public for personal use. More and more individuals personally own powerful mobile devices, such as smartphones, that, in addition to serving as a cellular phone, can be used in many of the same ways as a desktop or a laptop, such as accessing emails, browsing documents or the internet, game playing, listening to audio or viewing a video, and personal information management (PIM).

Due to the above trends in mobile devices, enterprises are currently experiencing an "invasion" of personal devices into the workplace. Given the sophisticated capabilities of their personal mobile devices, employees no longer desire possessing a separate personal and business mobile device and continually pressure information technology (IT) departments to support personal devices brought into the workplace. As such, IT departments struggle to maintain a proper balance between enabling a certain level of access to enterprise data (e.g., such as access to email, contacts, documents, and the like) on personal devices and ensuring adequate security measures to protect corporate intellectual property in such enterprise data. This phenomenon has led enterprises to investigate the viability of a "Bring Your Own Device" (BYOD) strategy to IT, where a personal mobile device is provisioned by IT departments with the capability of operating as a complete business mobile device in a secure fashion.

Such a BYOD strategy could significantly decrease IT costs (e.g., by eliminating or reducing the need to purchase and provision hardware devices) and provide mobile enterprise access to many more employees than was previously possible (e.g., due to cost concerns), thereby achieving greater increases in productivity than before. However, significant challenges arise in provisioning "work environment" on a personal mobile device that maintains adequate security and data partitioning between the employee's "personal world" and the employer's "business world."

SUMMARY

One or more embodiments of the invention provide virtualization as the solution for consolidating personal and busi-

ness uses in a single mobile device. One feature of virtualization is that it preserves isolation of the personal and work environments. As a result, the user need not provide enterprise IT departments any control of the user's personal environment and the enterprise IT departments can retain strict control of the user's work environment. Another feature of virtualization is that the user's work environment will be platform independent. In other words, regardless of the type of personal mobile device the user chooses, the resulting business mobile device through virtualization will be identical. Therefore, enterprise IT departments need to support only one type of business mobile device.

One method of provisioning a business mobile device on a personal mobile device, according to one or more embodiments of the invention, comprises binding a mobile application for provisioning the business mobile device to a privileged component of a host operating system of the personal mobile device, wherein the binding enables a hypervisor component and a management service component of the mobile application to execute in a privileged mode. The mobile application is then able to download a virtual phone image for the business mobile device and security-related policy settings relating to use of the business mobile device from a mobile management server managed by an employer of a user of the personal mobile device, wherein the hypervisor component is able to launch a virtual machine for the business mobile device based on the virtual phone image. Once the virtual phone image has been downloaded, the method continues by initiating a periodic attempt to establish a connection between the management service component of the mobile application and the mobile management server to comply with the downloaded security-related policy settings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of an example use case in which embodiments may be practiced.

FIG. 2 depicts an embodiment of a mobile management platform that may be utilized by an IT department to provision a business mobile device on a personal mobile device **100**.

FIGS. 3A-3E depict embodiments of an administrator user interface of a administration service for provisioning a business mobile device on a personal mobile device.

FIG. 4 depicts an internal system architecture of a personal mobile device that supports a business mobile device according to an embodiment.

FIG. 5 is a flow that illustrates a process for provisioning a virtual phone image for a business mobile device on a personal mobile device.

FIG. 6 is a flow that illustrates a process for establishing leasing communications between a mobile management platform server and a personal mobile device.

DETAILED DESCRIPTION

FIG. 1 is an illustration of an example use case in which embodiments may be practiced. As depicted, an IT department **115** of an enterprise **110** may provide the capability to "provision" a software-based business mobile device **105** that runs on an employee's personal mobile device **100**. Such provisioning (e.g., delivery of business mobile device **105** to personal mobile device **100**) may be performed "over-the-air" through a wireless network (e.g., WiFi network, etc.), cellular network **120** or combination thereof. In certain embodiments, as described herein, such a software-based business mobile device **105** takes the form of a virtual

3

machine that runs on top of a software virtualization layer (also sometimes referred to herein as a hypervisor) supported by the “host” operating system (e.g., Android™, iOS™, Symbian™, webOS™, etc.) of personal mobile device **100** (such virtual machine sometimes also referred to herein as a “virtual phone”).

FIG. 2 depicts an embodiment of a mobile management platform that may be utilized by IT department **115** to provision a business mobile device on personal mobile device **100**. As depicted, a mobile management platform server **200** (e.g., software-based) is installed on a computer system of IT department **115** and provides a number of functional components. Through human interface devices (e.g. mouse, keyboard, touchscreen, etc.), an administrator can interact with an admin user interface **205** to access an admin service component **210**, which, as further discussed below, offers a variety of services to assist the administrator in provisioning a business mobile device **105** on a personal mobile device **100**. As depicted in the embodiment of FIG. 2, admin service component **210** may further include a virtual phone provisioning service component **215** that establishes a connection (e.g., wireless) with personal mobile device **100** in order to deliver a virtual phone image for business mobile device **105** to personal mobile device **100** and a virtual phone leasing service component **220** that periodically communicates (e.g., wirelessly) over time with personal mobile device **100** (e.g., once business mobile device **105** has been installed on personal mobile device **100**), for example, in order to ensure compliance with certain security policies regarding the user’s ability to access an installed business mobile device **105** or to provide updates to the virtual phone image of business mobile device **105**. Admin service component **210** accesses a mobile management database **225** in order to manage and store, for example, user profiles, group profiles (e.g., business groups of an enterprise, such as sales, marketing, legal, finance, engineering, etc.), business mobile device policies (as further described below), virtual phone images for business mobile devices, mobile applications that may be included in virtual phone images, etc. In one embodiment, mobile management database **225** may comprise a relational database to store user profiles, groups profiles and business mobile device policies as well as a file system based repository to store various virtual phone images and mobile applications.

FIGS. 3A-3E depict embodiments of an admin user interface **205** of an admin service **210**. In one embodiment, admin user interface **205** and admin service **210** are implemented as a web application accessible through a web browser although alternative embodiments may be implemented differently, including, for example, as a standalone client-side application. FIG. 3A illustrates an embodiment of an initial “dashboard” view that is displayed, for example, when an administrator initially logs into admin service **210** through admin user interface **205**. The left side of FIG. 3A provides a navigation panel enabling an administrator to manage and view various settings relating to users that have been provisioned with business mobile devices, business group configurations for business mobile devices, policy settings for business mobile devices, various virtual phone images for business mobile devices, mobile applications that can be provisioned to business mobile devices and other configuration information. As illustrated, the dashboard’s main view provides an overview of recent administration activities (e.g. “activity feed”) and other usage statistics. FIG. 3B illustrates a user view displaying information relating to users who have been provisioned a business mobile device by mobile management server **200**. As FIG. 3B depicts, users may be organized into a variety of business groups or organizations within enter-

4

prise **110**, such as sales, marketing, finance, legal, engineering and the like. As further described below, in certain embodiments, such business groups are able to set their own default policies and default virtual phone images for users in their groups. The user view of FIG. 3B also indicates a status of the business mobile device **105** provisioned by admin service **210** to each user. Such status of a user’s business mobile device may be, for example, active, inactive, locked, wiped, pending installation, and the like. In certain embodiments of this user view and as further described below, an administrator is able to request that mobile management platform **200** (e.g., via virtual phone leasing component **215**, etc.) “wipe” a particular user’s business mobile device **105** from the personal mobile device **100** (e.g., delete the virtual phone image or otherwise remove the functionality of business mobile device **105**), for example, when such user has left enterprise **110** and is no longer an employee. It should be recognized that such a wiping of business mobile device **105** does not affect the user’s ability to use personal mobile device **100**. FIG. 3C illustrates a group view displaying information relating to business mobile devices configured for a particular business group within enterprise **110**, such as the sales group. As depicted, the group view of FIG. 3C displays a business mobile device policy that has been set for the sales group (i.e., the “default policies set”) as well as a virtual phone image that has been set for the sales group (i.e., the “default virtual phone template”). The group view of FIG. 3C further displays users belonging to the sales group who have been provisioned a business mobile device as well as enables the administrator to create, store and modify new and existing groups.

FIG. 3D illustrates an embodiment of a policy setting view of admin user interface **210**. As depicted, the policy setting view of FIG. 3D enables an administrator to view, create, store and modify different policies for managing business mobile devices. Such policies, for example and as illustrated in FIG. 3D, may include “lease” renewal settings including an “interval” setting defining how often virtual phone leasing service **220** and personal mobile device **100** attempt to establish communications, an “auto disable” time period setting, expiration (e.g., time period expires without an intervening interval communication with virtual phone leasing service **220**) of which may trigger personal mobile device **100** to temporarily disable business mobile device **105** (e.g., putting business mobile device **105** into a “locked” state that prevents a user from utilizing business mobile device **105** until a successful communication by personal mobile device **110** with virtual phone leasing service **220**), an “auto wipe” time period setting, expiration (e.g., time period expires without an intervening interval communication with virtual phone leasing service **220**) of which may trigger personal mobile device to permanently “wipe,” deactivate or otherwise remove business mobile device **105** from personal mobile device **100**, etc. Other security related policy settings may also be configured in the policy setting view of FIG. 3D including, for example, whether a password is required to access business mobile device **105**, the type and strength of the password (PIN, etc.), expiration periods for passwords, length of inactivity time before business mobile device **105** presents a lock screen, amount of retries before business mobile device **105** locks, etc. Other policy settings in embodiments may include whether business mobile device **105** may be accessible by VPN, whether a debugging mode can be set on business mobile device **105** to assist an administrator to troubleshoot issues, whether data can be cut and paste and shared between personal mobile device **100** and business mobile device **100**, and the like.

5

FIG. 3E illustrates an embodiment of a virtual phone image view of administrator user interface **210**. Through this view, an administrator is able to view, create, store and modify base virtual phone images for business mobile devices (e.g., according to requirements of different business groups in enterprise **110**) that can be delivered to personal mobile device **100**. Such a base image or “template” may include a selected mobile “guest” operating system (e.g., Android, iOS, Symbian, webOS, etc.), selected default user settings or customizations for the mobile operations system (e.g., wallpaper, shortcuts, sounds, security settings, network settings, third part service synchronization settings, etc.), selected installed default mobile applications, and the like. FIG. 3A also illustrates additional views accessible from the left side navigation panel that an administrator may desire to select in order to manage business mobile device activity. For example, the “work phone images” button enables the administrator to view current virtual phone images that have been uploaded into mobile management database **225** as well as to upload new virtual phone images. Similarly, the “applications” button enables the administrator to view current mobile applications that have been uploaded into mobile management database **225** and may be added to an existing or new virtual phone template. Such an applications view may further enable the administrator to upload additional mobile applications from third party sources such as various third party application stores (e.g., Android Market, Apple App Store, Amazon Appstore, carrier applications stores, etc.). The “configuration” button may enable the administrator to view currently scheduled jobs that have been scheduled by the administrator (e.g., delivery of virtual phone images to personal mobile devices, updates to existing virtual phone images that have already been installed on personal mobile devices, requests to wipe virtual phone images from personal mobile devices, etc.), a list of administrators in IT department **115** and other configuration information.

It should be recognized that the views of FIGS. 3A-3E are merely exemplary and that alternative embodiments of admin user interface **205** and admin service **210** may implement different user interfaces with different design decisions that offer different management functions than those depicted in FIGS. 3A-3E. For example, embodiments of administration service **210** may further provide an administrator a capability to maintain a menu of “a la carte” mobile applications that can be separately provisioned to a particular user’s business mobile device **105**, for example, upon request of such user and separate from any default mobile applications that are included in virtual phone images.

FIG. 4 depicts an internal system architecture of personal mobile device **100** that supports a business mobile device according to an embodiment. Personal mobile device **100** includes a firmware operation system (OS) **400**, such as Android, iOS, Symbian, webOS, etc. In the embodiment of FIG. 4, a virtual phone “enabler” component **405** is embedded into firmware OS **400**. Because it is embedded into firmware OS **400**, enabler component **405** is able to execute certain of its functions in privileged modes (e.g., superuser, root access, etc.) that are typically reserved for functions of firmware OS **400**. For example, in one embodiment, upon a launch of business mobile device **105** by a user (e.g., by selecting a “work phone” icon displayed on personal mobile device **100**, etc.), enabler component **405** loads a virtual phone image for business mobile device **105** into the memory of personal mobile device **100** and dedicates a thread for the execution of a virtual machine for business mobile device **105**. During execution of the virtual machine for business mobile device **105**, other portions of enabler component **405**

6

may then generally support the transfer of control between firmware OS **400** and business mobile device **105** (sometimes referred to as “world switching”). In addition to the foregoing, in certain embodiments, portions of enabler component **405** may further assist with issues such as memory allocation, timers, power management, communications between a hypervisor **415** (as further discussed below) running on top of firmware OS **400** and a virtual hardware platform (sometimes referred to herein as a “virtual machine monitor”) of the virtual machine for business mobile device **105**, enabling networking capabilities (e.g., TCP/IP, IPv4/IPv6, etc.) for the virtual machine of business mobile device **105** and the like. In one embodiment, enabler component **405** is embedded into firmware OS **400** by a mobile device manufacturer or a carrier **430**, such that a personal mobile device **100** purchased by a user (e.g. via generally available methods such as carrier stores, electronics stores, consumer goods stores, ecommerce web sites, etc.) already includes enabler component **405**.

A personal mobile device **100** having firmware OS **400** that includes enabler component **405** is able to support a mobile application package **410** that comprises a variety of functional components such as a hypervisor **415**, a provisioning tool **420** and a management service **422**. In one embodiment, a user may download mobile application package **410** from a mobile application store **435** such as the Android Market, Apple App Store, Amazon Appstore, etc. For example, such a mobile application package **410** may take the form of a .apk file if downloaded from the Android Market. Once downloaded and installed on the host OS of personal mobile device **100**, mobile application package **410** authenticates and binds itself to enabler component **405**, thereby enabling the various functional components of mobile application package to execute in higher privileged and/or secured modes. Hypervisor **415** is a virtualization layer running on top of firmware OS **400** which provides necessary services to enable execution of a virtual machine for business mobile device **105**. In one embodiment, the guest OS included in a virtual phone image **425** for business mobile device **105** includes “paravirtualized” guest drivers for each device of personal mobile device **100** that enables a virtual hardware layer (or virtual machine monitor) of the virtual machine to intercept hypercalls for device specific behavior and forward such hypercall requests as needed to hypervisor **415**, which in turn facilitates communication with the actual hardware devices of personal mobile device **100**. It should be recognized that alternative embodiments may utilize a non-paravirtualized implementation where guest drivers and the guest OS of virtual phone image **425** may be unaware that they are running on top of a virtualization layer. As further depicted in FIG. 4, mobile application package **410** also includes a provisioning tool **420** that may, for example, provide a user interface and other support services to assist a user in retrieving virtual phone image **425** and other configuration information (e.g., policy configurations, additional mobile applications, etc.) from virtual phone provisioning service **215** of mobile management server **200** in IT department **115**. Mobile application **410** further includes a management service **422** that once installed, continuously runs as a service on the host OS and periodically communicates with virtual phone leasing service, for example, in order to comply with various security policy settings for business mobile device **105** or to provide various updates (e.g., OS updates, customizations, new applications, etc.) to virtual phone image **425** of business mobile device **105**. In one embodiment, because management service **422** is able to run in a higher privilege or security level due to its binding to enabler component **405**, it cannot be

manually terminated by the user of personal mobile device **100** (e.g., without such user obtaining root access, etc.).

FIG. 5 is a flow that illustrates a process for provisioning virtual phone image **425** for business mobile device **105** on personal mobile device **100**. In step **500**, a user purchases personal mobile device **100** including firmware OS **400** that includes enabler component **405**. In step **505**, the user, for example, using a mobile app store application already installed on personal mobile device **100** (or through alternative downloading means), purchases or otherwise downloads and installs mobile application package **410** on the host OS of personal mobile device **100**. Upon installation of mobile application package **410**, in step **510**, the user launches provisioning tool **420** of mobile application package **410**. In one embodiment, provisioning tool **420** provides a user interface to the user to input information into provisioning tool **420** that enables provisioning tool **420** to establish a connection (e.g., wireless) to virtual phone provisioning service **215**. For example, an administrator of IT department may, via an out-of-band channel (e.g., orally, email, support ticket, etc.), provide the user a URL to input into provisioning tool **240** which identifies a network address (e.g., and listening port) of mobile management platform **200** and/or unique identifying information (e.g., user ID, etc.) that virtual phone provisioning service **215** can utilize to match a virtual phone image **425** that corresponds to the user. Alternatively, a user may alternatively provide such unique identifying information (e.g., enterprise username and password, etc.) to provisioning tool **420** or provisioning tool **420** may extract such a unique identifying information from personal mobile device **100** itself (e.g., user's cell phone number, etc.). Upon receipt of such unique identifying information from provisioning tool **420**, virtual phone provisioning service **215** is able to identify a virtual phone image **425** that corresponds to the user. In an alternative embodiment, virtual phone provisioning service **215** may utilize push methodologies to transmit a push message to personal mobile device **100** that wakes-up provisioning tool **420** on personal mobile device **100** in order to establish a connection back to virtual phone provisioning service **215**. In one such embodiment, such a push message may include unique identifying information corresponding to the user which provisioning tool **420** can transmit back to virtual phone provisioning service **215** to enable virtual phone provisioning service **215** to identify a virtual phone image **425** corresponding to the user (or alternatively, provisioning tool **420** can prompt the user for such unique identifying information, such as a username and password or extract such unique identifying information from personal mobile device **100**, such as a cell phone number).

In step **515**, provisioning tool **420**, as described above, establishes a connection (e.g., wireless) with virtual phone provisioning service **215** and provides the unique identifying information to virtual phone provisioning service **215** to identify a virtual phone image **425** corresponding to the user. In step **520**, virtual phone provisioning service **215** receives the unique identifying information and, in step **525**, dynamically generates or otherwise identifies a previously stored default virtual phone image **425** corresponding to the unique identifying information (and thus, the user). For example, in one embodiment, virtual phone provisioning service **215** determines an identity of the user from the received unique identifying information and is able to identify a default virtual phone image **425** stored in a file system repository of mobile management database **225** that corresponds to the business group of the user (see, e.g., FIG. 3C). In step **530**, virtual phone provisioning service **215** transmits virtual phone image **425** to provisioning tool **420**. In one embodiment, such

virtual phone image **425** is transmitted as a zip file. In step **535**, virtual phone provisioning service **215** similarly identifies policy settings corresponding to the user's business group (see, e.g., FIG. 3D) as well as any additional mobile applications requested by the user (and supported by IT department **115**) that are not included in virtual phone image **425**, and in step **540**, transmits the policy setting and additional mobile applications to provisioning tool **420**. In one embodiment, communication between virtual phone provisioning service **215** and provisioning tool **420** during transmission of virtual phone image **425**, business group policy settings, and additional mobile applications occurs through RESTful APIs (representational state transfer application programming interface). In steps **545** and **550**, provisioning tool **420** receives virtual phone image **425**, group policy settings and additional mobile applications, respectively. In one embodiment, provisioning tool **240** receives and stores virtual phone image **425**, due to its size (e.g., 3 GBs or higher in some embodiments), on an external storage card of personal mobile device **100**, such as an external microSD card or other similar small form factor mass storage devices. Alternative embodiments may store virtual phone image **425** in the internal memory (e.g., NAND flash memory or embedded eMMC/eSD memory chips) of personal mobile device **100**. In step **555**, provisioning tool **420** initializes business mobile device **105**. For example, in one embodiment, during such initialization, provisioning tool **420** provides certain group policy settings received in step **550**, such as lease settings, to management service **422** to initiate a periodic "leasing" communication with virtual phone leasing service **220** in accordance with the lease settings for the user's business group (see, e.g., FIG. 3D). Similarly, provisioning tool **420** may provide other group policy settings, such as password settings, to hypervisor **415** to enable hypervisor **415** to properly control password access to business mobile device **105**. The initialization process may additionally install any additional mobile applications into virtual phone image **425**. Once initialized, in step **560**, the user may launch business mobile device **105** in a virtual machine supported by hypervisor **415** using virtual phone image **425**. Similarly, once virtual phone image **425** has been delivered and installed on personal mobile device **100**, at step **565**, mobile management platform **200** may update a user profile corresponding to the user (see, e.g., FIG. 3B) to indicate that the user's business mobile device **105** has now been activated.

FIG. 6 is a flow that illustrates a process for establishing lease communications between a mobile management platform server **200** and a personal mobile device **100**. As previously discussed, in certain embodiments, once virtual phone image **425** has been delivered, stored and installed, management service **422** of mobile application package **410** begins periodic "lease" communications with virtual phone leasing service **220** of mobile management platform **200**. In certain embodiments, for security purposes, management service **422** runs in a privileged mode in the host OS of personal mobile device **100** such that management service **422** cannot be manually terminated by the user. In step **600**, management service **422** initiates or starts a periodic timer for a lease interval, such as 12 hours (see, e.g., FIG. 3D). Upon expiration of the lease interval in step **605**, management service **422** attempts to establish a connection with virtual phone leasing service **220**. If, in step **610**, a connection is successfully established, then in step **615**, management service **422** communicates with virtual phone leasing service **220** and downloads any updates, changes and/or modifications to any settings for business mobile device **105** and modifies virtual phone image **425**, hypervisor **415** settings (e.g., password

security settings for business mobile device **105**), management service **422** configuration settings (e.g., lease settings) and/or other settings and configurations accordingly. Such updates, changes, and/or modifications may include, for example, instructions to wipe business mobile device **105** from personal mobile device **100** (e.g., due to the user no longer being an employee at enterprise **115**), new mobile applications to install on business mobile device **105**, instructions to remove existing mobile applications from business mobile device **105**, upgrades to the guest OS of business mobile device **105**, changes to user settings and customizations for guest OS of business mobile device **105**, changes to the group policy settings of the user, changes to shared preferences for mobile applications, and the like. In one embodiment, an administrator using mobile management platform server **200** may interact with user interface **205** to request any of the foregoing updates, changes and/or modifications to business mobile device **105**, which are then queued until management service **422** successfully establishes a connection with virtual phone leasing service **220**. After performing such updates, changes, and/or modifications by management service **422**, in step **620**, management service **422** resets its periodic timer and returns to step **605**.

If, however, in step **610**, a connection is not successfully established (e.g., due to a malicious user who has stolen personal mobile device **100** and turned off its wireless network capabilities), then in step **625**, if a time period for an auto-wipe setting (e.g., 4 days in FIG. 3D) has elapsed, then in step **630**, management service **422** will permanently delete or otherwise remove virtual phone image **425** from personal mobile device **100** thereby permanently wiping the existence of business mobile device **105** from personal mobile device **100** for security purposes. It should be recognized that the wiping of business mobile device **105** from personal mobile device **100** does not affect a user's ability to use personal mobile device **100**. If, the time period for auto-wipe has not elapsed, then, in step **635**, if a time period for an auto-disable setting (e.g., 1 day in FIG. 3D) has elapsed, then, in step **640**, management service **422** will temporarily disable access by the user to business mobile device **105** until a connection with virtual phone leasing service has been re-established in step **610**. It should be recognized that the flow of FIG. 6 for lease communications is merely exemplary and various alternatives may be made consistent with the teachings herein. For example, while FIG. 6 describes a "polling" technique in which management service **422** running on personal mobile device **100** initiates an attempt to establish communications with virtual phone leasing service **220** of mobile management platform **200**, alternative embodiments may employ a push model, whereby virtual phone leasing service **220** utilizes a periodic timer to transmit push messages to management service **422** on personal mobile device **100** to request management service **422** to connect back to virtual phone leasing service **220**.

Although one or more embodiments of the present invention have been described in some detail for clarity of understanding, it will be apparent that certain changes and modifications may be made within the scope of the claims. For example, while embodiments herein have referred to certain mobile operating systems such as Android, it should be recognized that any mobile operating systems may be utilizing in alternative embodiments such as Apple's iOS, Research In Motion's Blackberry OS, Microsoft's Windows Phone, Hewlett Packard's webOS, Symbian, Java, and the like. Similarly, while embodiments herein have generally utilized a smartphone as an example of a mobile device, it should be recognized that any portable device that has primary purposes

of providing mobile computing or mobile data services to a user may utilize the techniques herein, including tablet computers and similar portable devices. It should further be recognized that use of certain terminology that may be more commonly used with certain operating systems than others is merely exemplary not meant to limit the scope of the teachings herein to any particular operating system and that corresponding functions and components in other operating system platforms may benefit from the teachings herein. Accordingly, the described embodiments are to be considered as illustrative and not restrictive, and the scope of the claims is not to be limited to details given herein, but may be modified within the scope and equivalents of the claims. In the claims, elements and/or steps do not imply any particular order of operation, unless explicitly stated in the claims.

The various embodiments described herein may employ various computer-implemented operations involving data stored in computer systems. For example, these operations may require physical manipulation of physical quantities—usually, though not necessarily, these quantities may take the form of electrical or magnetic signals, where they or representations of them are capable of being stored, transferred, combined, compared, or otherwise manipulated. Further, such manipulations are often referred to in terms, such as producing, identifying, determining, or comparing. Any operations described herein that form part of one or more embodiments of the invention may be useful machine operations. In addition, one or more embodiments of the invention also relate to a device or an apparatus for performing these operations. The apparatus may be specially constructed for specific required purposes, or it may be a general purpose computer selectively activated or configured by a computer program stored in the computer. In particular, various general purpose machines may be used with computer programs written in accordance with the teachings herein, or it may be more convenient to construct a more specialized apparatus to perform the required operations.

The various embodiments described herein may be practiced with other computer system configurations including hand-held devices, microprocessor systems, microprocessor-based or programmable consumer electronics, minicomputers, mainframe computers, and the like.

One or more embodiments of the present invention may be implemented as one or more computer programs or as one or more computer program modules embodied in one or more computer readable media. The term computer readable medium refers to any data storage device that can store data which can thereafter be input to a computer system—computer readable media may be based on any existing or subsequently developed technology for embodying computer programs in a manner that enables them to be read by a computer. Examples of a computer readable medium include a hard drive, network attached storage (NAS), read-only memory, random-access memory (e.g., a flash memory device), a CD (Compact Discs)—CD-ROM, a CD-R, or a CD-RW, a DVD (Digital Versatile Disc), a magnetic tape, and other optical and non-optical data storage devices. The computer readable medium can also be distributed over a network coupled computer system so that the computer readable code is stored and executed in a distributed fashion.

Virtualization systems in accordance with the various embodiments, may be implemented as hosted embodiments, non-hosted embodiments or as embodiments that tend to blur distinctions between the two, are all envisioned. Furthermore, various virtualization operations may be wholly or partially implemented in hardware. For example, a hardware imple-

11

mentation may employ a look-up table for modification of storage access requests to secure non-disk data.

Many variations, modifications, additions, and improvements are possible, regardless the degree of virtualization. The virtualization software can therefore include components of a host, console, or guest operating system that performs virtualization functions. Plural instances may be provided for components, operations or structures described herein as a single instance. Finally, boundaries between various components, operations and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the scope of the invention (s). In general, structures and functionality presented as separate components in exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the appended claims(s).

What is claimed is:

1. A method of provisioning a business mobile device on a personal mobile device comprising:

binding a mobile application for provisioning the business mobile device to a privileged component of a host operating system of the personal mobile device, wherein the binding enables a hypervisor component and a management service component of the mobile application to execute in a privileged mode, wherein the privileged component is embedded into the firmware of the personal mobile device;

downloading, through the mobile application, a virtual phone image for the business mobile device and security-related policy settings relating to use of the business mobile device from a mobile management server managed by an employer of a user of the personal mobile device, wherein the hypervisor component is able to launch a virtual machine for the business mobile device based on the virtual phone image;

initiating a periodic attempt to establish a connection between the management service component of the mobile application and the mobile management server to comply with the security-related policy settings;

permanently removing the virtual phone image of the business mobile device upon expiration of an auto-wipe time period specified in the security-related policy settings, wherein the management service component cannot be terminated by the user of the personal mobile device; and

temporarily disabling access to the business mobile device upon expiration of an auto-disable time period specified in the security-related policy settings, wherein the auto-disable time period is shorter than the auto-wipe time period, wherein permanently removing the virtual phone image of the business mobile device upon expiration of the auto-wipe time period specified in the security-related policy settings comprises permanently removing the virtual phone image of the business mobile device without affecting a personal use of the personal mobile device upon expiration of the auto-wipe time period specified in the security-related policy settings.

2. The method of claim 1, wherein the binding step comprises an authentication of the mobile application to the privileged component.

3. The method of claim 2, wherein the privileged component facilitates transfer of control between the host operating

12

system of the personal mobile device and the virtual machine of the business mobile device.

4. The method of claim 1, wherein the mobile application is downloaded by the user to the personal mobile device from a mobile application store.

5. The method of claim 1, wherein the downloading step is performed by a provisioning component of the mobile application.

6. The method of claim 5, wherein the user provides the provisioning component of the mobile application with a network address of the mobile management server.

7. The method of claim 1, wherein the security-related policy settings comprise an interval time period to establish communications between the management service component and the mobile management server.

8. The method of claim 1, wherein the initiating step is performed by the management service component.

9. The method of claim 1, further comprising downloading any updates to the business mobile device from the mobile management server upon successfully establishing a connection between the management service component and the mobile management server during a periodic attempt.

10. The method of claim 1, wherein the security-related policy settings comprise information regarding whether a password is required to access the business mobile device, information regarding the type and the strength of the password and information regarding an expiration period for the password.

11. The method of claim 10, wherein the security-related policy settings further comprise information regarding a length of inactivity time before the business mobile device presents a lock screen and information regarding an amount of retries before the business mobile device locks.

12. The method of claim 1, wherein the binding enables the hypervisor component and the management service component of the mobile application to have the superuser privilege over the host operating system of the personal mobile device.

13. The method of claim 1, wherein the binding enables the hypervisor component and the management service component of the mobile application to have root access to the host operating system of the personal mobile device.

14. The method of claim 1, further comprising upon the launch of the virtual machine for the business mobile device, loading the virtual phone image for the business mobile device into a memory of personal mobile device and dedicating a thread for the execution of the virtual machine for the business mobile device.

15. The method of claim 1, wherein the virtual phone image of the business mobile device comprises a mobile guest operating system, user settings for the mobile guest operating system and default mobile applications installed in the mobile guest operating system.

16. The method of claim 15, wherein the user settings for the mobile guest operating system comprise at least one of a wallpaper, a shortcut, a sound, a security setting, a network setting and a third part service synchronization setting of the mobile guest operating system.

17. A mobile device configured to support a virtual business mobile device comprising a processor configured to perform the steps of:

binding a mobile application for provisioning the virtual business mobile device to a privileged component of a host operating system of the mobile device, wherein the binding enables a hypervisor component and a management service component of the mobile application to

13

execute in a privileged mode, wherein the privileged component is embedded into the firmware of the mobile device;

downloading, through the mobile application, a virtual phone image for the virtual business mobile device and security-related policy settings relating to use of the virtual business mobile device from a mobile management server managed by an employer of a user of the mobile device, wherein the hypervisor component is able to launch a virtual machine for the virtual business mobile device based on the virtual phone image;

initiating a periodic attempt to establish a connection between the management service component of the mobile application and the mobile management server to comply with the security-related policy settings;

permanently removing the virtual phone image of the virtual business mobile device upon expiration of an auto-wipe time period specified in the security-related policy settings, wherein the management service component cannot be terminated by the user of the mobile device; and

temporarily disabling access to the virtual business mobile device upon expiration of an auto-disable time period specified in the security-related policy settings, wherein the auto-disable time period is shorter than the auto-wipe time period, wherein permanently removing the virtual phone image of the virtual business mobile device upon expiration of the auto-wipe time period specified in the security-related policy settings comprises permanently removing the virtual phone image of the virtual business mobile device without affecting a personal use of the mobile device upon expiration of the auto-wipe time period specified in the security-related policy settings.

18. The mobile device of claim 17, wherein the binding step comprises an authentication of the mobile application to the privileged component.

19. The mobile device of claim 18, wherein the privileged component facilitates transfer of control between the host operating system of the mobile device and the virtual machine of the virtual business mobile device.

20. The mobile device of claim 17, wherein the mobile application is downloaded by the user to the mobile device from a mobile application store.

21. The mobile device of claim 17, wherein the downloading step is performed by a provisioning component of the mobile application.

22. The mobile device of claim 21, wherein the user provides the provisioning component of the mobile application with a network address of the mobile management server.

23. The mobile device of claim 17, wherein the security-related policy settings comprise an interval time period to establish communications between the management service component and the mobile management server.

24. The mobile device of claim 17, wherein the initiating step is performed by the management service component.

25. The mobile device of claim 17, wherein the processor is further configured to perform the step of downloading any updates to the virtual business mobile device from the mobile management server upon successfully establishing a connection between the management service component and the mobile management server during a periodic attempt.

26. A non-transitory computer readable storage medium including instructions that cause a processor of a mobile device to provision a virtual business mobile device by perform the steps of:

14

binding a mobile application for provisioning the virtual business mobile device to a privileged component of a host operating system of the mobile device, wherein the binding enables a hypervisor component and a management service component of the mobile application to execute in a privileged mode, wherein the privileged component is embedded into the firmware of the mobile device;

downloading, through the mobile application, a virtual phone image for the virtual business mobile device and security-related policy settings relating to use of the virtual business mobile device from a mobile management server managed by an employer of a user of the mobile device, wherein the hypervisor component is able to launch a virtual machine for the virtual business mobile device based on the virtual phone image;

initiating a periodic attempt to establish a connection between the management service component of the mobile application and the mobile management server to comply with the security-related policy settings;

permanently removing the virtual phone image of the virtual business mobile device upon expiration of an auto-wipe time period specified in the security-related policy settings, wherein the management service component cannot be terminated by the user of the mobile device; and

temporarily disabling access to the virtual business mobile device upon expiration of an auto-disable time period specified in the security-related policy settings, wherein the auto-disable time period is shorter than the auto-wipe time period, wherein permanently removing the virtual phone image of the virtual business mobile device upon expiration of the auto-wipe time period specified in the security-related policy settings comprises permanently removing the virtual phone image of the virtual business mobile device without affecting a personal use of the mobile device upon expiration of the auto-wipe time period specified in the security-related policy settings.

27. The non-transitory computer readable storage medium of claim 26, wherein the binding step comprises an authentication of the mobile application to the privileged component.

28. The non-transitory computer readable storage medium of claim 27, wherein the privileged component facilitates transfer of control between the host operating system of the mobile device and the virtual machine of the virtual business mobile device.

29. The non-transitory computer readable storage medium of claim 26, wherein the mobile application is downloaded by the user to the mobile device from a mobile application store.

30. The non-transitory computer readable storage medium of claim 26, wherein the downloading step is performed by a provisioning component of the mobile application.

31. The non-transitory computer readable storage medium of claim 30, wherein the user provides the provisioning component of the mobile application with a network address of the mobile management server.

32. The non-transitory computer readable storage medium of claim 26, wherein the instructions further cause the processor to perform the step of downloading any updates to the virtual business mobile device from the mobile management server upon successfully establishing a connection between the management service component and the mobile management server during a periodic attempt.

33. The non-transitory computer readable storage medium of claim 26, wherein the security-related policy settings com-

15

prise an interval time period to establish communications between the management service component and the mobile management server.

34. The non-transitory computer readable storage medium of claim **26**, wherein the initiating step is performed by the management service component.

* * * * *

16